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Nutrient Tracking for Water Quality Evaluation: A Case Study of Domestic and Industrial Discharges in Lagos State

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ABSTRACT

The release of nutrient-rich effluents from domestic and industrial sources pollutes surface waters, triggering eutrophication and hypoxia. This study assesses wastewater quality, nutrient levels, and regulatory compliance, highlighting implications for aquatic ecosystems and public health. Water samples were collected from seven points across domestic and industrial discharges weekly for three weeks, following standard sampling protocols. Physicochemical parameters such as pH, turbidity, conductivity, total dissolved solids (TDS), chloride, alkalinity, hardness, dissolved oxygen (DO), chemical oxygen demand (COD), and biochemical oxygen demand (BOD) were analyzed using standard methods, while UV-Visible spectrophotometry was used to determine nutrient indicators (phosphate and nitrate). The result showed wide variations across sites with pH ranging from 6.19 to 8.82, while high turbidity reflected elevated solids. COD (31.8 - 292 mg/L) and BOD (5.55 - 71.3 mg/L) indicated significant organic pollution and microbial activity, corresponding to low DO values. Phosphate and nitrate levels were moderate, ranging from 0.01 - 0.44 mg/L and 0.29 - 2.95 mg/L, respectively, and were within acceptable limits. Wastewater from domestic and industrial sources showed notable differences in characteristics compared to control samples. The study reveals that domestic and industrial wastewater significantly contribute to nutrient pollution, posing environmental risks to aquatic ecosystems. These findings emphasize the urgent need for enhanced, sustainable wastewater management practices to protect water resources.

KEYWORDS: Effluents, Hypoxia, Nutrients, Sustainability.

1. INTRODUCTION

Water is a vital natural resource under threat from untreated wastewater containing pollutants like organic matter, heavy metals, and nutrients[1]. These compromise water quality, harm aquatic ecosystems, and pose health risks, particularly in developing countries with inadequate treatment infrastructure. Lagos, with over 20 million inhabitants, generates massive volumes of untreated domestic and industrial wastewater daily, often discharged into waterways leading to nutrient accumulation, eutrophication, leading to hypoxia and habitat degradation[2 – 4]. The consequences include biodiversity loss, livelihood impacts, and waterborne diseases[5]. Several studies have documented high nutrient levels in Lagos surface waters, particularly nitrates and phosphates[1,6], however, there remains paucity of comparative analysis of nutrient concentrations and other physicochemical properties of domestic and industrial wastewater sources within the same geographical zone. These gaps pose a threat to achieving Sustainable Development Goals, including good health and well-being, clean water and sanitation, and life below water SDGs 3, 6 and 14, respectively. This study seeks to assess nutrient levels in domestic and industrial wastewater discharges across Lagos State, aiming to identify key gaps and inform effective wastewater management strategies.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in three major urban districts of Lagos State; Shomolu, Surulere, and Ikeja representing distinct socio-economic, residential and industrial characteristics with well geo-referenced sampling points (Table 1, Figure 1).

Table 1: Description of Sampling Locations

Sampling Points	Discharge Points	GPS Coordinate	Description of Study Area
Point A	Domestic Kitchen	6.53728 N 3.37732 E	Houses, shops and borehole
Point B	Domestic Laundry	6.53728 N 3.37732 E	Houses, shops and borehole
Point C	Canteen	6.53785 N 3.37490 E	Houses, small shops, eatery and borehole
Point D	Laundry Service	6.53789 N 3.37504 E	Houses, shops and borehole
Point E	Industry 1	6.47894 N 3.36202 E	Movement of heavy-duty vehicles, industrial operations and warehouses
Point F	Industry 2	6.58849 N 3.37591 E	Heavy vehicular movements, industrial operations and high traffic zone
Point G	Treated Effluent	6.58848 N 3.37592 E	Heavy vehicular movements, industrial operations and high traffic zone

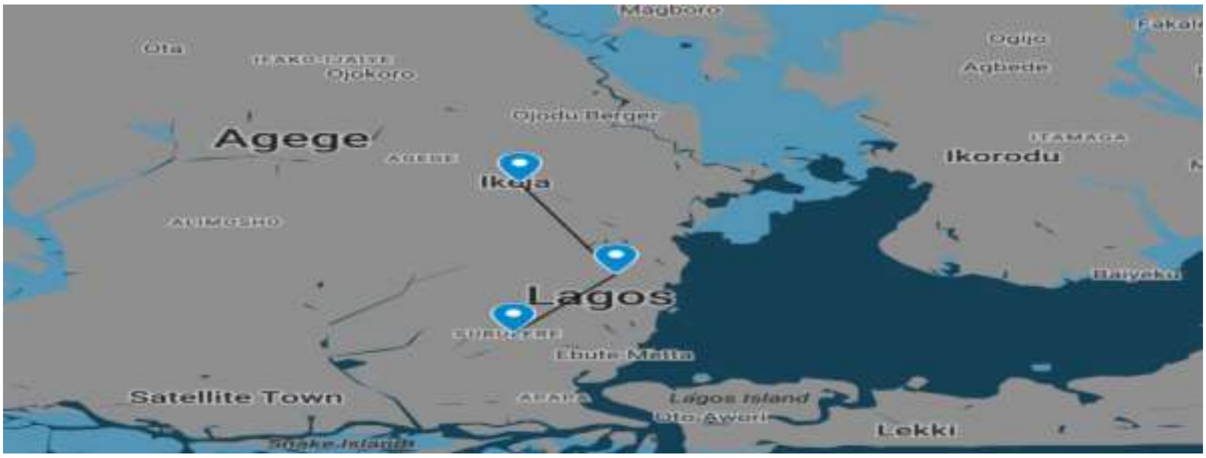

Figure 1. Map showing the study area

2.2 Sampling and Laboratory Analysis

Sampling occurred weekly over three events between June and July 2025, with 21 samples collected from domestic, commercial, and industrial discharge points, which were geo-referenced. Samples were collected in pre-cleaned 2.5 L polyethylene containers, stored in an ice chest, and transported to the laboratory. In-situ data were collected using a Horiba-U50 multi-parameter meter. Laboratory analysis followed APHA protocols, with phosphate and nitrate concentrations determined using a UV-Visible spectrophotometer at 880 nm and 420 nm, respectively[7,8].

3. RESULTS AND DISCUSSION

The physicochemical parameters and nutrient loads of the wastewaters demonstrated variability across the samples, as presented in Table 2 and Figures 2-5. Notably, samples F (from an industrial area with significant vehicular activity) and G (control sample) were clear, whereas the remaining samples were cloudy. Samples B, C, and D, obtained from domestic canteens and commercial laundry facilities, displayed a slightly soapy appearance. Furthermore, samples A, B, C, and D emitted an objectionable odour, in contrast to samples E, F, and G, which were unobjectionable. The pH of the samples was within the permissible threshold of 6.0 – 9.0 as set by NESREA and LASEPA, ranged from 6.19 – 8.82 for all the samples with a temperature range of 27.2 – 27.8 ^{O}C (Figure 2a). In Figure 2b, turbidity, TSS and TS were observed to be relatively high (Table 2) while TDS was observed to be lower than permissible threshold of 2,000 mg/L. Locations A, B, C and D were particularly observed to have higher threshold possibly because the wastewater being discharged were untreated resulting in low ORP values in the range of 50.7 – 163 mV and DO values ranging from 2.35 to 4.35 mg/L (Figure 2a). Similarly, BOD, COD, Chloride, Alkalinity and Hardness showed higher concentrations being discharged to the immediate drainage within the environment. While phosphate and nitrate were notably below the permissible threshold, the risk of accumulated discharge to the environment following other physicochemical effect of wastewaters could be detrimental to the immediate water body.

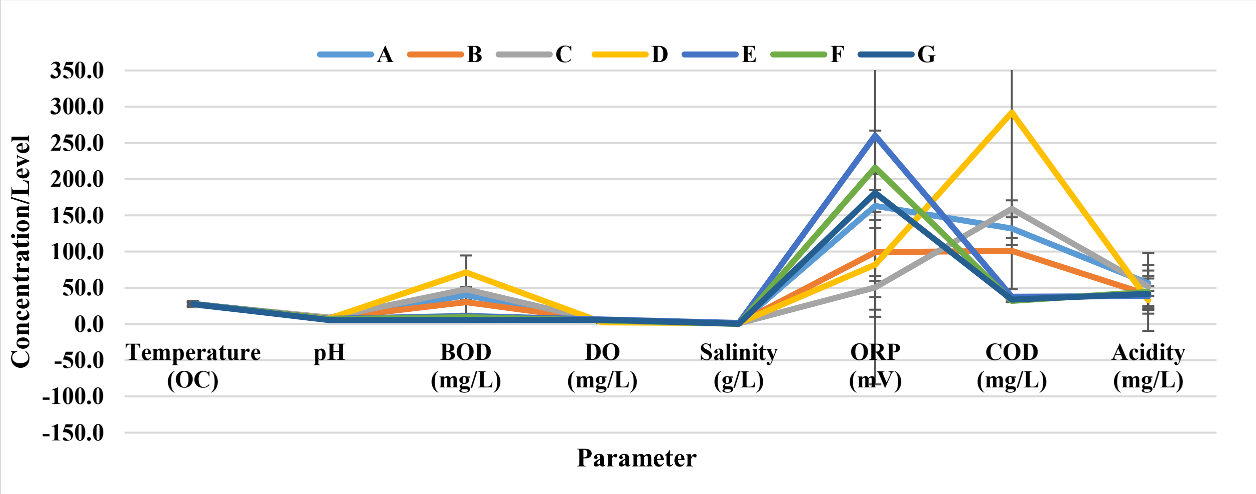

Figure 2a: Variation of Physicochemical Parameters at the Sampling Locations

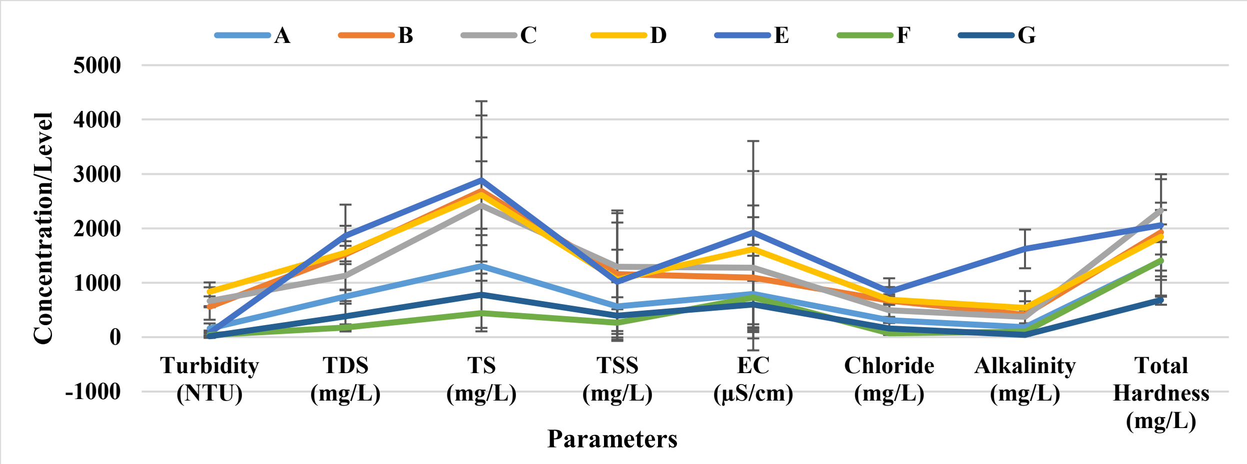

Figure 2b: Variation of Physicochemical Parameters at the Sampling Locations

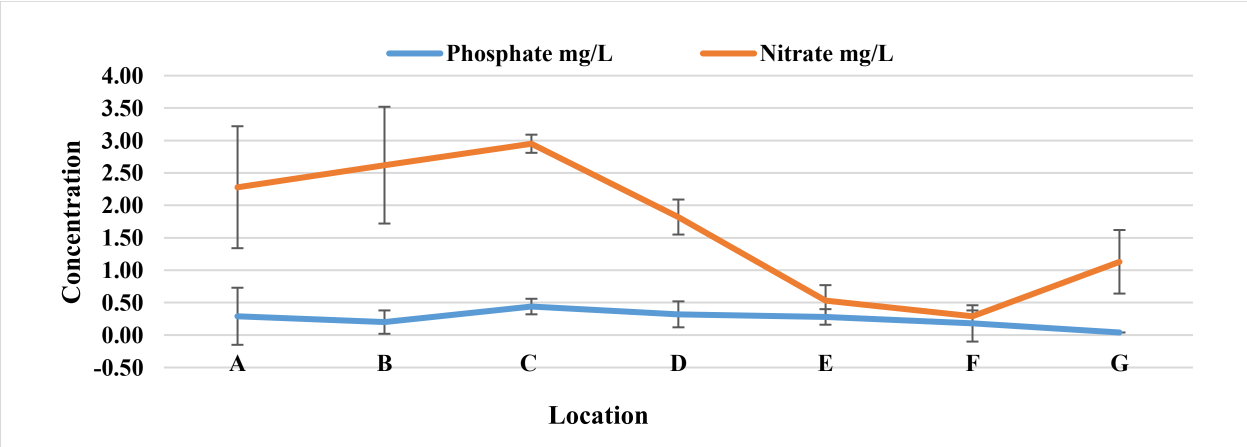

Figure 3: Results of Phosphate and Nitrate Concentrations across the Sampling Locations

Table 2: Range of Data and Permissible Limit of Effluent Discharges

Parameters	Range	NESREA/LASEPA LIMIT
Temperature, ^{O}C	27.2 - 27.8	NS
pH	5.51 - 8.82	6.0 - 9.0
BOD, mg/L	5.55 - 71.3	< 20
DO, mg/L	2.35 - 6.48	NS
Salinity, g/L	0.13 - 1.51	NS
Turbidity, NTU	15.9 – 833	<10
TDS, mg/L	179 – 1863	< 2000
TS, mg/L	443 – 2883	NS
TSS, mg/L	264 – 1292	< 750
EC, µS/cm	599 – 1921	<1000
ORP, mV	50.7 – 260	NS
COD, mg/L	31.8 – 292	< 40
Chloride, mg/L	73.7 – 836	< 350
Acidity, mg/L	32.6 - 56.1	NS
Alkalinity, mg/L	44 – 1622	NS
Total Hardness, mg/L	680 – 2328	NS
PO_4^{3-} mg/L	0.04 - 0.44	< 3.5
NO_3^- mg/L	0.29 - 2.95	< 10

National Environmental Standards and Regulations Enforcement Agency, 2011[9]
Lagos State Environmental Protection Agency, 2019 [10]
*NS - Not Specified

3.1 Relationship between physicochemical characteristics

The statistical correlation at $P < 0.05$ and $P < 0.01$(95% and 99% confidence limit, respectively) between physicochemical characteristics of the wastewater samples are presented in Table 3.

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Table 3: Pearson Correlation of Different Parameters

	Temp., °C	pH	ORP mV	EC µS/cm	Turbidity NTU	DO mg/L	TDS mg/L	Salinity g/L	Acidity mg/L	Alkalinity mg/L	Total Hardness mg/L	Chloride mg/L	TS mg/L	TSS mg/L	COD mg/L	BOD mg/L	PO_4^{3-} mg/L	NO_3^- mg/L
Temp. °C	1																	
pH	0.739	1																
ORP mV	-0.520	-0.693	1															
EC µS/cm	0.375	0.536	-0.027	1														
Turbidity NTU	0.619	0.808(*)	-0.891(**)	0.425	1													
DO mg/L	-0.533	-0.416	0.774(*)	-0.068	-0.776(*)	1												
TDS mg/L	0.513	0.592	-0.202	0.900(**)	0.536	-0.095	1											
Salinity g/L	0.499	0.589	-0.191	0.907(**)	0.530	-0.086	1.000(**)	1										
Acidity mg/L	0.281	-0.044	-0.083	-0.491	-0.247	-0.074	-0.448	-0.464	1									
Alkalinity mg/L	0.167	0.240	0.380	0.886(**)	-0.012	0.364	0.789(*)	0.798(*)	-0.393	1								
Total Hardness mg/L	0.799(*)	0.912(**)	-0.398	0.745	0.630	-0.268	0.738	0.736	-0.046	0.549	1							
Chloride mg/L	0.500	0.588	-0.190	0.906(**)	0.529	-0.084	1.000(**)	1.000(**)	-0.462	0.798(*)	0.736	1						
TS mg/L	0.590	0.733	-0.371	0.862(*)	0.653	-0.184	0.978(**)	0.975(**)	-0.361	0.696	0.816(*)	0.975(**)	1					
TSS mg/L	0.656	0.886(**)	-0.603	0.723	0.778(*)	-0.308	0.853(*)	0.848(*)	-0.191	0.486	0.863(*)	0.848(*)	0.944(**)	1				
COD mg/L	0.519	0.501	-0.746	0.372	0.870(*)	-0.933(**)	0.401	0.395	-0.184	-0.066	0.403	0.392	0.463	0.520	1			
BOD mg/L	0.642	0.582	-0.786(*)	0.364	0.885(**)	-0.942(**)	0.415	0.406	-0.053	-0.068	0.491	0.404	0.495	0.577	0.985(**)	1		
PO_4^{3-} mg/L	0.798(*)	0.774(*)	-0.495	0.577	0.620	-0.559	0.497	0.491	0.270	0.314	0.850(*)	0.490	0.595	0.694	0.601	0.695	1	
NO_3^- mg/L	0.660	0.613	-0.870(*)	-0.014	0.699	-0.599	0.271	0.252	0.387	-0.274	0.413	0.252	0.424	0.624	0.559	0.655	0.520	1

***. Correlation is significant at the 0.05 level (2-tailed).**
****. Correlation is significant at the 0.01 level (2-tailed).**

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Dissolved oxygen showed a positive relationship with ORP (r = 0.774) and negative with turbidity at (r = -0.776). Turbidity, which is a measure of light attenuation due to suspended particles positively correlated with suspended solids (r = 0.778), COD (r = 0.870) and BOD (r = 0.885), and negatively correlated with DO (r = - 0.776). this possibly explains the pollution status of the wastewater being discharged occasionally. Similarly, a negative relationship was observed in DO, COD and BOD at (r = -0.933 and r = -0.942), respectively. Furthermore, the high suspended solids observed in the wastewater samples also showed positive relationship with TDS, salinity, hardness and chloride at r = 0.853, r = 0.848, r = 0.863 and r = 0.848, respectively. These relationships reflect in the moderate relationship with phosphate and nitrate which has the tendencies of enriching connecting surface water and instigating oxygen stress in surface waters.

4. CONCLUSION

The study assessed nutrient levels and key water quality parameters in domestic and industrial wastewater discharges across Shomolu, Surulere, and Ikeja in Lagos State, Nigeria. Results showed domestic and industrial wastewater contribute to nutrient pollution, with high solids, turbidity, COD, and BOD levels. Phosphate and nitrate levels, though within limits, suggest ongoing nutrient enrichment that may cause eutrophication and oxygen stress in surface waters if not managed. The findings emphasize the need for community-level wastewater pretreatment, enforcing discharge regulations, and raising public awareness on sustainable waste practices to reduce nutrient loading and improve urban water quality.

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